HYDRO - ELECTRIC POWER DEVELOPMENT ON THE TALLAPOOSA RIVER IN ALABAMA

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Proposed

Hydro-Electric Power Development

on the

Tallapoosa River in Alabama.

A THESIS

PRESENTED BY

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In these days of electrical progress when the demand for power is increasing daily, a good deal of attention is being given to the question of how to supply that demand in the most satisfactory way and at the lowest cost to all parties concerned. Steam, gas, gasoline, oil and water are used successfully as power for generating electricity, but where natural power in the form of falling water is plentiful, the very best opportunity for the generation of electric power is afforded. It is the purpose of this paper and the drawings which accompany it to set forth the complete design of a plant suitable for utilizing the energy of one of the water powers of Alabama. This waterpower is located on the Tallapoosa river in the state of Alabama and is known as the"Cherokee Power Site." It is in the east central part of the state and is about eighteen miles south of Sturdevant and about thirty miles northeast of Montgomery. It is capable of developing forty-two thousand horse power and its qualifications as a power site are considered exceptionally good.

At this point the Tallapoosa river channel converges until it is only three hundred feet wide, as can

be seen by referring to the contour map, Plate 1. On either side of the river the banks rise quite abruptly to a height of one hundred feet above the low water mark of the stream and are of such contour that a dam giving an eighty foot head of water could be con-structed. The construction of this dam would back the water up for twanty miles and would create a reservoir the average width of which would be half a mile, and the storage capacity of which would be about five million cubic feet. At the site of the dam the bed and banks of the river are of granite and the river bed proper is free from boulders and deposit, conditions which greatly facilitate the building and anchoring of a dam.

Just below the dam the river makes a sharp bend toward the east. A high point of land is thus left projecting into the river channel. The power house would be located on the south bank of this promentory and directly behind it the bluff would be excavated to form a forebay one hundred and eighty feet wide, three hundred and fifty feet long and averaging twelve feet deep. The floor of the forebay would average sixty-eight feet above the low water mark of the river. Six large pen-

stocks, one for each generator water-wheel, and a seventh smaller penstock for the exciter water wheel would lead from the south end of the forebay to the power house, a distance of about one hundred feet. The screens and controlling gates would be placed at the south or lower end of the forebay. A retaining wall runs across the lower end of the forebay and for a distance of about one hundred feet north on either side of the bay. At the end of the retaining wall on the west side of the forebay the spillway begins and follows a northwesterly direction to the opposite bank of the river. The spillway is somewhat curved or convex in order to better withstand the water pressure behind it. It is divided into three sections, a main spillway and two auxilliary spillways. The crest of the main spillway is one foot lower than that of the auxilliary spillway, the latter serving as an overflow during the flood stages of the river. The main spillway spans the deepest part of the river channell and is four hundred feet in length and one hundred and five feet high at the deepest part of the river. The auxilliary spillway on the east side of the river proper is about three hundred and thirty feet in length and that on the west is about three

hundred and forty feet long. At the deepest section of the river bed the base of the dam is one hundred and fifteen feet in width and the bases of other section are in proportion. The different sections of the spillway and retaining wall are shown in an accompanying drawing, Plate #2. Another drawing gives the plan view of the entire dam, Plate #3. Most of the retaining wall will be thirty five feet high and twenty six feet wide at the bottom. The top is sixteen feet wide. The spillway will be built of large blocks of granite quarried from the surrounding hills and will be faced with a layer of masonry and rough rocks.

The following are the calculations made for the spillway and retaining wall:-

The cross section of the dam was divided into ten sections and the area of each section was measured with a planimeter. The areas are as follows:- Section C C.

Section 1	- 144 sq. ft.	Section 6	- 616 sq. ft.
" 2	- 280 " "	" 7	- 728 " "
" 3	- 368 " "	" 8	- 822 " "
" 4	- 460 " "	" 9	- 973 " "
" 5	- 554 " "	" 10	-1902 " "

Total area of section 6847 sq. ft. (Sect. C.C.)

Assume 1 cu. ft. of granite weighs 150# .

Total weight of unit length (1 ft.) of dam (or spillway) at section C-C. 150 x 6847 = 1,027,050# = 513.5 tons.

The spillway is 134 feet wide at section C - C.

$$\frac{513.5}{134} = 3.83 \text{ tons per sq. ft.} = 7660\# \text{ per sq. ft.}$$

$$\frac{7660}{144} \quad 53\# \text{ per sq. in. average pressure.}$$

Maximum pressure 95.5 x 150 = 14320# per sq. ft. equals

$$\frac{14320}{144} = 100\# \text{ (almost) per sq. in.}$$

$$\frac{47 \times 105.5}{2} \times 62.5 = 155{,}000\# \text{ total weight of water}$$

wedge above section C-c for unit length.

$$\frac{(105.5)^2}{2} \times 62.5 = 348000\# \text{ total horizontal pressure}$$

on water side of dam.

Resultant (total) water pressure normal to water side of dam. $\sqrt{(155000)^2 + (348000)^2} = 381000\#$

Tangent of the angle between the vertical and the water side of dam $\frac{47}{105.5} = .445$ or

$$\frac{\text{vertical water pressure}}{\text{Horizontal water pressure}} = \frac{155000}{348000} = .445$$

The angle equals 24 degrees.

Resultant of weight of dam (spillway) and water pressure normal to water side (by graphical method - see Plate #2) equals 650 tons.

Coefficient of friction for granite granite .70

Resistance of dam to sliding .70 x 1,027,050 718935#.

Horizontal force 348000#

There fore section C-C is safe against sliding.

Factor of Safety 2.075

Section A - A.

Area 1252 sq. ft.

Weight of unit length 1252 x 150 188000# 94.0 tons.

$\frac{94}{5075}$ = 1852 tons/sq. ft. = 3705#/sq. ft.

$\frac{3705}{144}$ = 2575#/sq. in.

$\frac{20.12 \times 45.6}{2} \times 62.5$ = 28,700# total weight of water wedge above unit length of dam.

$\frac{(45.6)^2}{2} \times 62.5$ = 65000# total horizontal pressure on water side of dam.

$\sqrt{(28700)^2 + (65000)^2}$ = 71,100# = 35.55 tons - Resultant water pressure normal to water side of dam.

Resultant of weight of sectional water pressure resultant equals 144 tons (by graphical method - see Plate #2)

Total weight of section 188,000#

u equals .7

P = u f = .7 x 188,000 = 131,600# resisting force of section against sliding.

Horizontal water pressure 65,000#

Section is safe against sliding. F.S. = 2.022.

Sections B.-B. and D.-D.

Area - 3972 sq. ft.

3972 x 150 = 596,000# = 298 tons.

$\frac{298}{85.5}$ = 3,485 tons per sq. ft. = 6970#/sq.ft.

$\frac{6970}{144}$ = 48.4#/sq. in.

$\frac{36.5 \times 85}{2} \times 62.5$ = 96,800# total weight of water wedge above unit length of section.

$\frac{(85)^2}{2} \times 62.5$ = 225,500# total horizontal water pressure on dam.

$\sqrt{(96800)^2 + (225,500)^2}$ = 245,500# = 122.757 tons - Resultant water pressure normal to dam.

Resultant of weight of dam and water resultant 368.75 tons (by graphical method - see Plate #2)

Total weight of section - 596,000#

u = .7

P = u f = .7x596000 = 417,200# resisting force of the dam (sec B B or D D) against sliding.

Horizontal force against section 225,500#

Therefore sections B B and D D are safe against sliding F.S. 1.85.

Section E - E.

Area = 1806 sq. ft.

1806 x 150 = 271000# = 135.5 tons.

$\frac{135.5}{59.5}$ = 2.28 tons/sq. ft. = 4560#/sq. ft.

$\frac{4560}{144}$ = 31.65# per sq. inch.

$\frac{24.25 \times 55.7}{2} \times 62.5$ = 42,250# total weight of water wedge above unit length of section.

$\frac{(55.7)^2}{2} \times 62.5$ = 96750# total horizontal pressure on water side of dam.

$\sqrt{(42250)^2 + (96,750)^2}$ = 105,600# = 52.8 tons. - Resultant water pressure normal to dam.

Resultant of weight of dam and water pressure normal to it 167.5 tons (obtained graphically - see plate #2)

Total weight of section 271000#

u = .7

P = u f = .7 x 271000 = 189700# resisting force exerted by dam (section E-E) against sliding.

Horizontal water pressure 96750#.

Therefore section E - E is safe against sliding. F.S. equals 1.96

Section C - C.

$$N = \frac{1}{2} - \frac{1}{3}\,\frac{h'y'}{c'} \times \frac{b' + b''}{b'}$$

$$= \frac{1}{2} - \frac{1}{3}\,\frac{105 \times 150}{60{,}000} \times \frac{107 + 13}{107}$$

$$= \frac{1}{2} - \frac{1}{3} \times 0.262 \times 1.12$$

$$= \frac{1}{2} - 0.098 = 0.402$$

$h' = 105$
$y' = 150$
$b'' = 13$
$c' = 60{,}000$
$b' = 107$

$$N = \frac{1}{6}\left[\frac{2\,c'b'}{b'y'\,(b' + b'')} - 1\right]$$

$$\frac{1}{6}\left[\frac{2 \times 60{,}000 \times 107}{105 \times 150 \times 120} - 1\right]$$

$$\frac{1}{6}\left[6.8 - 1\right] = \frac{1}{6} \times 5.8 = 0.96$$

Therefore section C - C is safe.

Sections B - B and D - D.

$$N = \frac{1}{2} - \frac{1}{3}\,\frac{h'y'}{c'} \times \frac{b' + b''}{b'} \qquad H$$

$$= \frac{1}{2} - \frac{1}{3} \times \frac{80 \times 150}{60{,}000} \times \frac{130 + 13}{130}$$

$$= \frac{1}{2} - .0735 = 0.4265$$

$h' = 80$
$y' = 150$
$b' = 130$
$b'' = 13$
$c' = 60{,}000$

$$N\ \frac{1}{6}\left[\frac{2 \times 60{,}000 \times 130}{80 \times 150 \times 143} - 1\right]$$

$$\frac{1}{6}\left[9.08 - 1\right] = \frac{1}{6} \times 8.08 = 1.35$$

Therefore sections B - B and D - D are safe.

Retaining Wall.

For Unit Length:-

16 x 35 = 560 cu. Ft.

1/2 x 8 x 35 = 140 " "

700 " " total volume of unit length

150

105000# total vertical pressure.

0.7

73500.0# resisting force against sliding.

Horizontal pressure of water against wall (normal) equals

$\frac{(30)^2 \times 62.5}{2} = 28,120\#$

Facotr of safety $\frac{73500}{28,120} = 2.61$

Horizontal pressure of water against wall (high-water)

equals $\frac{(35)^2 \times 62.5}{2} = 38,200\#$

Factor of safety $\frac{73500}{38200} = 1.92$

Calculations for Penstocks and Fore Bay.

Number of generating units = 6

H.P. of one generating unit = 6000.

$Q = \frac{36000 \times 550}{62.5 \times 80 \times .80} =$ 4950 or say 5000 sec. ft.

Velocity of water in head race - assumed as 4 ft/ sec.

Area $\frac{5000}{4} = 1250$ sq. ft.

Area through screens $\frac{5000}{2} = 2500$ sq. ft.

Using 6 circular steel penstocks, each to carry $\frac{5000}{6}$ or 840 sec. ft., at full gate; assume a maximum velocity of 12 ft. per sec. in the penstocks. -

Area $\frac{840}{12} = 70$ sq. ft. $= \frac{\pi D^2}{4}$

$D = \sqrt{\frac{70}{.7854}} = 9.46$ or say 10 ft.

Therefore diameter of penstocks 10 ft.

Forebay Cross-section:-

Area - 1250 sq. ft.

Width - 180 feet.

Then depth $= \frac{1250}{180} = 6.95$ ft.

Increase this depth to 12 ft.

The building.

The main building is approximately two hundred feet long, seventy feet wide and forty-five feet high. At the center of the downstream side of the building an extension projects a few feet from the main structure; the extension is fifty feet long and fifty five feet in height. The walls will be of masonry and the framework of steel. The entire roof is supported by steel trusses. The floors are of concrete reenforced and supported by I-beams. Lighting of the building is accomplished by numerous side windows in the daytime and by arc and incandescemt lamps at night.

The generating room runs the full length of the building and is sixty-nine feet in width. In this room are located the water wheels, the generators, the motor driven exciters and the water driven exciter. At one side are the transformers arranged in groups of three, each group being enclosed in a masonry compartment. Each transformer is mounted on a separate truck which runs on small rails set in the floor. By this means any transformer may be disconnected and pushed right out on to the generating floor where it can be handled by crane. For moving heavy machinery a crane of sixty-nine foot span runs the whole length of the generating room. The structure which supports the crane consists of built up

coloumns of steel and these columns form part of the main structure itself. A short spur of railroad track extends into one corner of the generating room for the purpose of facilitating the installation and removal of heavy machinery.

On the ground floor and running parallel with the generating room for nearly the full length of the building is a room thirty feet wide for auxillary apparatus. This "room" is in reality several smaller rooms for some of the auxillary apparatus is partitioned off into small rooms. Here are located the piping, tanks, pumps and other necessary apparatus for handling the oil for insulating the transformers and the water for cooling them. The bank of three transformers used for the station load with its oil switch and the compensator for starting the induction motor exciter sets are also located in this room. No definite qall divides this space off from the generating room but the masonry compartments for the transformer banks are ranged so closely along one side of the generating room that they practically form a wall between the two.

Directly above the room for auxillary apparatus is a gallery of the same width as the room below it and running the full length of the structure. It is

open on the side facing the generating floor and at its center where the bench board is located it projects slightly into the generating room in order that the operator may have a better view of the machines he is controlling. Directly behind the bench-board and just back of that a row of oil switches is placed. These are the machine switches and are six in number. Next farther back are the masonry compartments for the high tension bus bars. These compartments with their bus-bars are divided into two sections and a sectionalizing oil switch is inserted between them. Back of the high-tension bus-bars are located the two line oil switches and on the rear wall of the gallery vertical brick compartments are built into the wall to carry the high-tension line wires to the wire tower above. The gallery is reached by a circular stairway at either end.

Above the center of the gallery is located the wire tower, also reached by a circular stairway located in the center of the switch board gallery. It is about fifty feet long and forty-five feet wide and extends some ten feet above the roof of the main structure. In it are installed two sets of electrolytic lighting arresters and the necessary horn-gaps, choke coils, and

disconnect switches. On one side of this tower are the six outlets, one for each of the six line wires forming the two three-phase transmission lines.

An office is provided for in one corner of the building on the main floor. In another corner of the building is located a room for storage purposes and a small machine shop room. The löcker room is located in the gallery above the office.

Hydraulic Machinery.

The water for operating the turbines first passes through double screens placed just in front of the openings to the penstocks in the retaining wall at the lower end of the fore-bay. The screens consist of iron bars laid parallel to each other and an inch or two apart. Each screen is supported on an angle-iron frame work upon which it slides. When it becomes nesessary to clean the screens they may be hoisted out of the water by means of a small crane or derrick which runs along the top of the penstock wall on rails. The purpose of the screens is to prevent any foreign material from getting into the water wheels and causing trouble there.

In the mouth of each penstock is a gate valve which controls the flow of water into the penstock connected

with it. A motor connected to this valve and serves both for opening and for closing it. Each valve has its individual motor and each motor is arranged so that it may be controlled from the main switchboard within the station..

From the gate valves in the retaining wall six circular steel penstocks each ten feet in diameter carry the water directly to the water wheels withinthe station. The penstocks will be laid in trenches excavated out of the solid granite bank and will be anchored to the same. There are six water wheels or turbines each rated at six thousand horse power installed in the plant. They are made by the S. Morgan Smith Company of York, Pa., and are of the inward flow reaction type. There are two wheels mounted on the same horizontal axle in each turbine. The water from each penstock divides just before reaching the turbine and half goes to each wheel. The water enters from below at the rim of the wheel and leaves at the center of the wheel. A common discharge pipe located between the two wheels of each turbine serves to reunite the two streams of water after they have passed by separate paths through the two wheels and to conduct the water to the reenforced

concrete passage way under each turbine which leads to the tail-race. Each turbine is governed by a Lombard hydraulic governor which in turn is controlled from a switch on the bench board. The governor is mounted on the same base with the turbine and between its two wheels.

A penstock four feet in diameter supplies water to a small turbine used for driving an emergency exciter. Water for cooling the transformers is conveyed to the station from the forebay by a separate twelve inch main and after passing through a reducing valve is distributed to the cooling coils of the transformers through a system of piping shown in detail in the accompanying drawings Page 4, and #5.

Transformer Oil System.

The system for handling the transformer oil consists of three tanks, two oil pumps and a suitable system of piping. Referring to the drawings Plate #4, tank #1 is for old oil, tank #2 is for new oil, and tank #3 is for filtering and drying old oil. Tanks No. 1 and No. 2 are cylindrical tanks located under the floor of the auxilliary apparatus room. Tank #3 is square and is placed on the main floor.

The two oil pumps are also located on the main floor and are driven by small electric motors. Pump No. 1

handles old or drain oil only and transfer it form tank No. 1, the old oil tank, to tank No. 3, the filtering tank. The old oil drains by gravity from the transformers cases into tank No. 1. One of the principle reasons forfor gravity drain is that the transformer cases may be promptly emptied when a transformer burns out, even though the oil be burning. It is necessary therefore t that tank No. 1 and the piping leading from the transformer cases to it be perfectly air tight if they are to properly perform the function of extinquishing the flames from burning oil in an emergency. Pump No. 2 performs two duties. It may be used either to pump new oil from tank No. 2 into the trnasformer cases or to pump filtered oil from tank No. 3 into the transformer cases. Tank No. 3 and the two pumps are on the main floor level, but are enclosed in a separate oil room. This room also contains the pits in which tanks No. 1 and No. 2 are placed. An iron grating floor covers the pits. Two oil mains run along behind the transformer rooms, one for filling the transformer cases and the other for draining them. By the use of proper valves, the locations of which are shown on the drawings, the transfer of oil can be regulated at will. New oil on arriving at the

plant, is emptied into a receiving funnel on the generating floor from whence it flows by gravity into tank No. 2 for new oil.

Electrical Equipment.

Alternators.

The Alternators are six in number and are set in a row along the center of the generating floor, three on each side of a space in the center set apart for exciters. Each alternator is of 3500 kw. rating at unity power factor and generates 6600 volts at 60 cycles. Each machine is directly connected to a hydraulic turbine. These alternators are of General Electric Company manufacture. Their dimensions and spacings are given in detail on the drawings.

Exciters.

In the center of the generating floor are three exciter sets, two of which are motor driven and the third turbine driven. The two motor driven exciters are each of 150 kw. capacity and generate direct current at 125 volts. They are each driven by a 200 horse power induction motor of the squirrel cage type operating at 440 volts on 60 cycles. These motor generator sets are direct connected. One compensator serves to start either motor

a double throw switch mounted on each motor, serving to connect it with the compensator or the line when the motor is to be started. The third exciter is of 300 kw. capacity and generates direct current at 125 volts. It is directly connected to a 400 horsepower hydraulic turbine. The turbine is fitted with a Lombard govenor controlled from the switch board. All three exciters are flat compounded. The exciters and the two induction motors are of General Electric make and the turbine is furnished by the S. Morgan Smith Company. The exciters capacity about three percent of the total output of the station.

Transformers.

There are six sets or banks of main transformers, one bank for each alternator. Each transformer is rated at 1250 kw at unity power factor. This gives a rating of 3750 Kva for each bank of transformers - a rating slightly in excess of the alternator rating. Each bank is connected delta on both the low and the high sides and steps the voltage from 6600 volts up to 66000 volts. The grequency is 60 cycles. These transformers are water cooled and oil insulated. They are furnished by the General Electric Company.

A special bank of three transformers furnishes power for the station load. These transformers step the voltage down from 66,000 volts to 440 volts. Each transformer is rated at 156 kw. at unity power factor and the bank is rated at 468 kw. The frequency is 60 cycles. Insulation and cooling are both by oil. The connections are delta on both the high and low sides. The General Electric Company furnish these transformers also.

There are eighteen potential transformers in the plant, three for each alternator. They are all placed on the low side of the power transformers and step from 6600 volts down to 125 volts for the instruments on the switch board. There are two current transformers on the low side and two on the high side of each of the six main power transformer banks. The current from the secondary of these is used for operating switchboard instruments and relays. There are three current transformers on each of the two out going lines. They furnish current to switchboard instruments and relays. On the special bank of transformers for the station load there are two current transformers on the low side. All transformers are for 60 cycles and are of General Electric make.

Oil,Switches.

On the low side of each main bank of transformers

between the alternator and the transformer terminals is placed a K2 hand operated oil switch. These K2 switches are equipped with time-limit overload relays mounted at the switch.

On the high side an H3 oil switch is placed between the terminals of each transformer and the high tension bus-bars. These switches are all remote controll and are equipped with two-pole time-limit overload relays. The control switches and relays are mounted on the bench board.

The high tension bus-bar is divided into two sections and between them is mounted a non-automatic H3 oil switch, the control switch of which is mounted on one of the panel board sections inthe gallery.

The two out-going lines are each equipped with an H3 automatic oil switch and with a three-pole time limit overload relay. The remote control switch and the relay are mounted on the panel board in the gallery.

On the high side of the special station load transformer bank is placed a non-automatic H3 oil switch with remote control switch on the panel board in the gallery.

All oil switches are of General Electric con-

structure and are motor operated. On the drawings switches 1, 2, 3, 4, 5, and 6 are the machine switches for alternators 1, 2, 3, 4, 5, and 6 respectively, switch 7 is the high tension bus sectionalizing switch, switches 8 and 9 are the two line switches and switch 10 is the station load switch.

Switches, Instruments and Control Apparatus.

The main control board is a bench switch board consisting of nine panels or sections. Six of the sections, three on each end, are generator sections and the three center sections are exciter panels. Each section consists of a bench panel on which are mounted the control switches, signal lamps, and plug switches, and a small vertical panel just above it on which the instruments are mounted. The six alternator panels are duplicates of each other and are arranged in this manner. On each bench panel are mounted four remote control switches handles which control the alternator machine switch, the alternator field, the motor operated rheostat, and the turbine governor. The location of these switch handles is given on the drawing of the switch board. The control switches are of the Westinghouse type and are used on 125 volt circuits. Power for operating these switches is taken from the exciter bus.

Each control switch has two signal lamps, a red one to indicate when the switch is closed and a green one to indicate when it is open.

On the small vertical panel above each alternator bench panel are mounted six horizontal edge-wise indicating instruments - three ammeters, a voltmeter and a fieldammeter and an indicating wattmeter. The wires leading to these instruments are concealed within the pillars which support the vertical part of the board. The vertical instrument panels are supported on pillars so as to leave an open space between these panels and the bench panels through which the operator may see the machines he is controlling. On the front of each alternator section of the bench board are mounted a polyphase intergrating watt-hour meter and a two pole relay. The relay governs the oil switch between the high tension terminals of the transformers corresponding to that alternator and the high tension bus.

At one end of the bench board is a swinging panel which carries a synchroscope and a frequency meter. The wiring of the bench board is made accessible through two hinged doors, one at each end of the board.

The three central panels or sections of the bench

board are exciter panels. The center one of the three governs the turbo-exciter and the other two govern the two motor driven exciters. On the bench panel of the turbo-exciter section are mounted three switch handles - one governs the govenor on the turbine, the second governs the field rheostat on the turbo-exciter and the third governs the exciter switch which connects the exciter with the exciter bus. The other two exciter panels have mounted upon them only two switches each, a rheostat control switch and an exciter machine-switch. On the vertical panel above each exciter bench-panel are mounted an exciter voltmeter and an exciter ammeter.

The bench board is mounted on a small projecting balcony at the center of the switchboard gallery with its back to the generating room. A few feet from the front of the bench board is a vertical switchboard consisting of two panels. On one panel are two switch handles, one of which controls the sectionalizing switch and the other of which controls one of the outgoing line switches. The other panel also has two switch handles upon it - one controls the H3 switch on the high side of the station bank of transformers and the other controls the oil switch on the second outgoing line. At the top

of each panel are three line ammeters and at the bottom of each panel is a three pole time limit overload relay for the line.

On the main floor underneath the gallery is single vertical panel board for the 440 volt station load. On this board are mounted an ammeter, a voltmeter, a polyphase integrating watt hour meter, and a three-pole single-throw knife switch. This board controls the output from the secondary of the station bank of transformers.

All remote control switches on the bench board are Westinghouse type and all remote control switches on the panel boards are General Electric Type. All ammeters, voltmeters, and indicating wattmeters are of the Thompson horizontal edgewise type. Integrating watthour meters are General Electric type; likewise the synchroscope. The frequency meter is of the Thompson type. All the panels of the bench board and the vertical boards are of blue slate, enameled and polished.

Equipment in the Wire Tower.

The wire tower, located above the center of the switchboard gallery, contains, principally two sets of aluminum cell, electrolytic lightning arresters, one for each outgoing line. Each set consists of four arrester tanks, three of which are inserted between the line wires and the fourth between line and ground. Each set of

arresters is provided with three horn gaps and a switch for interchanging the connection two of the cells when charging them. The arrester cells and horn gaps are mounted on a frame work built of iron pipes. The arresters are charged by the General Electric Company's sector device. Each arrester is provided with a set of disconnects for insolating it from the line when an occasion to do so arises. In the wire tower are also mounted the choke coils, one for each line wire. These choke coils are of the hour glass type.

The two out-going three phase lines leave the building from one side of the wire tower through hooded outlets. Each three phase line has a separate hood extending over the three outlets for that line. The hoods are constructed of reenforced concrete and are designed to thoroughly protect the outlets from the weather. The apparatus installed in the wire tower is all of General Electric manufacture.

General Wiring Scheme.

and

System of Control.

In the wiring scheme each alternator and its set of three transformers form a unit, that is, each alternator is always used with the same bank of transformers. A K2

hand operated oil switch is inserted between each generator and its transformers. This switch is equipped with a time-limit overload relay which will protect the generator in case all other relays fail. It was made a hand operated switch because it seldom has to be opened and never under load conditions except when opened by the relay and also because it is a much less expensive switch than the H3 remote control type.

On the high side of the transformers each machine has its own H3 remote control switch between the high side of the transformer bank and the high side of the transformer bank and the high tension bus. All parallelling of machines is done on the high tension side. The high tension bus is divided into two parts and an H3 remote control switch is inserted between these two sections; this is termed the bus sectionalizing switch. Three generating units feed onto one section of the high tension bus and three onto the other.

One bus section connects directly to one of the out-going lines through an H3 remote control switch and the second bus section is connected in a similar manner to the other line. All H3 switches are motor operated and controlled from the switch board gallery. They are

all equipped with time -limit overload relays, either two pole or three pole as specified elsewhere, except the sectionalizing switch which is not-automatic. All oil switches are provided with a set of disconnects on each side of the switch in order that it may be entirely disconnected from the system for inspection and repairs.

The K2 oil switches are mounted in masonry compartments adjacent to their respective transformer banks and the relay for each switch is placed in the same compartment. The H3 switches are mounted in masonry compartments, each phase being placed in a cell by itself. The relays for these switches are mounted either on the bench board or on the panel baord in the gallery as described in another place. All connections to H3 switches are made from below while the connections to K2 switches are made from above.

The high tension bus bars are of hollow copper tubing. They are placed in masonry compartments, each conductor being mounted in a compartment by itself. All low tension wiring that has to traverse the floor space between the generators and the transformers is carried in shallow trenches built into the concrete floor for that purpose. Where open wiring is not objectionable the wires

are supported on suitable porcelain insulators. In laying out the wiring of the station the aim was to make it conform as nearly as possible with the principles of modern practice and at the same time to make it simple.

Some Date on the Plant.

Number of water wheel units = 6.

Horse power of each water wheel= 6000 H.P.

Total horse power of wheels 6 x 6000 = 36000 H.P.

Efficiency of wheels 80% (Assumed)

Power to be delivered to wheels $\frac{36000}{.80}$ = 45000 H.P.

$$H.P. = \frac{Q \times H \times y}{550}$$

where:- H.P.= horse power delivered to wheels.

H.= effective head of water on wheels in feed.

y. =density of water.

Q.= quantity of water supplied to wheels in second-feet.

$$45000 = \frac{Q \times 80 \times 62.5}{550}$$

Therefore $Q = \frac{550 \times 45000}{80 \times 62.5}$ = 4750 second feet.

From tables on page 44 "Water Powers of Alabama" by Hall we get:-

Q = 4070 second feet (at Sturdevant).

Also, it is stated there that the flow of water at the Cherokee power site is one fifth to one third greater than at Sturdevant.

Therefore, at the power site

$$Q = 4070 + \frac{4070}{5} = 4070 + 814 = 4884 \text{ sec. ft.}$$

$$Q = 4070 + \frac{4070}{3} = 4070 + 1353 = 5423 \text{ sec. ft.}$$

Both of these values of Q are greater than the required 4750 sec. ft. to run the plant so that there is sufficient flow of water to insure satisfactory operation of the water wheel.

Power delivered to generators = 36000 H.P. equals

$= .746 \times 36000 = 26850$ K.W.

Number of generators = 6

Rating of each generator = 35000 K.W.

Total capacity of generators at full load = 6×3500 equals 21000 K.W.

Total overload capacity of station 26850 - 21000 equals 5850 K.W.

Overload on each generator $= \frac{5850}{6} = 975$ K.W.

Percent overload that each generator may have to stand

$= \frac{975}{3500} \times 100$ equals 28%

The above figures are based on the assumption that the

efficiency of the generators is 100%. Now assume the efficiency of the generators is 90% and we get the following results:-

Total ove load capacity of station $= 26850 - \frac{21000}{.9}$

equals 26850 - 23444 equals 3406 K.W.

Overload on each generator $= \frac{3406}{6} = 568$ K.W.

Percent overload on each generator $= \frac{568}{3500} \times 100 = 19.7\%$

The last set of figures would correspond more nearly with actual running conditions.

Exciters.

Assume 2% of total generator capacity for exciters. Then exciter output $= .02 \times 21000 = 420$ K.W.

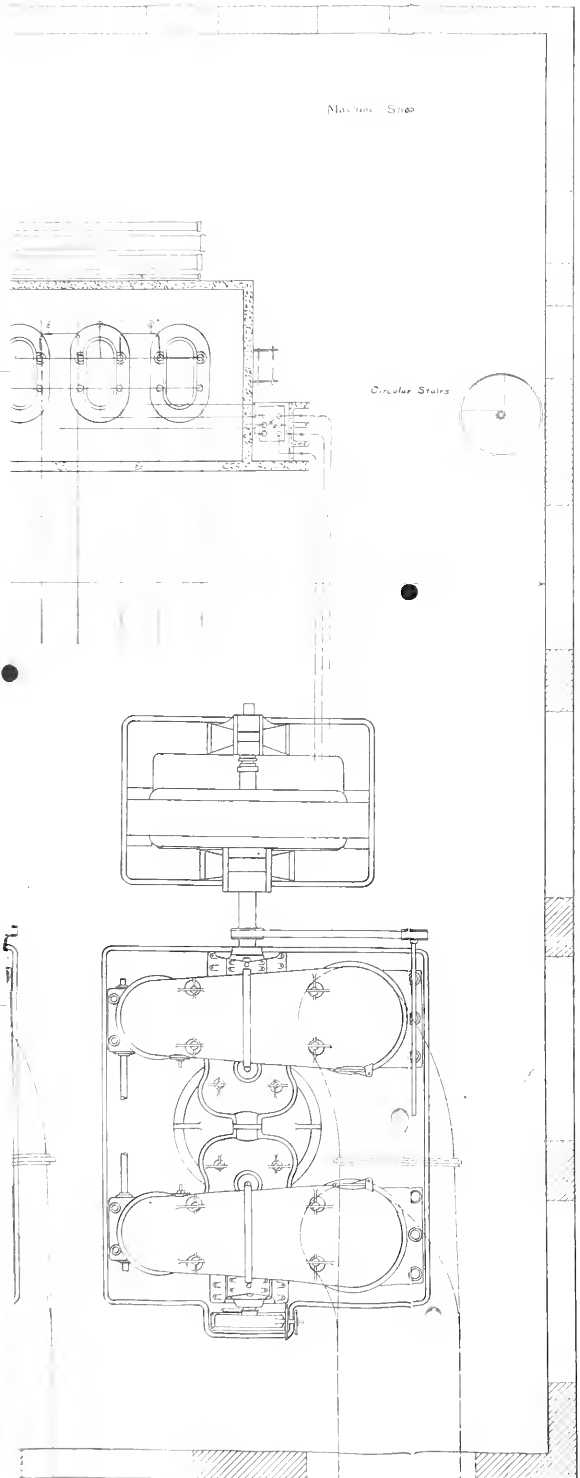
Assuming 90% efficiency.

Exciter input $= \frac{420}{.9} = 455$ K.W.

Increase this to 600 K.W. to allow for station lightingm motor power for operating control gates, signals and other station load.

The exciter capacity of 600 K.W. is divided up among three exciters, two of which are driven by direct connected induction motors and the third driven by a direct connected water turbine. The rating of

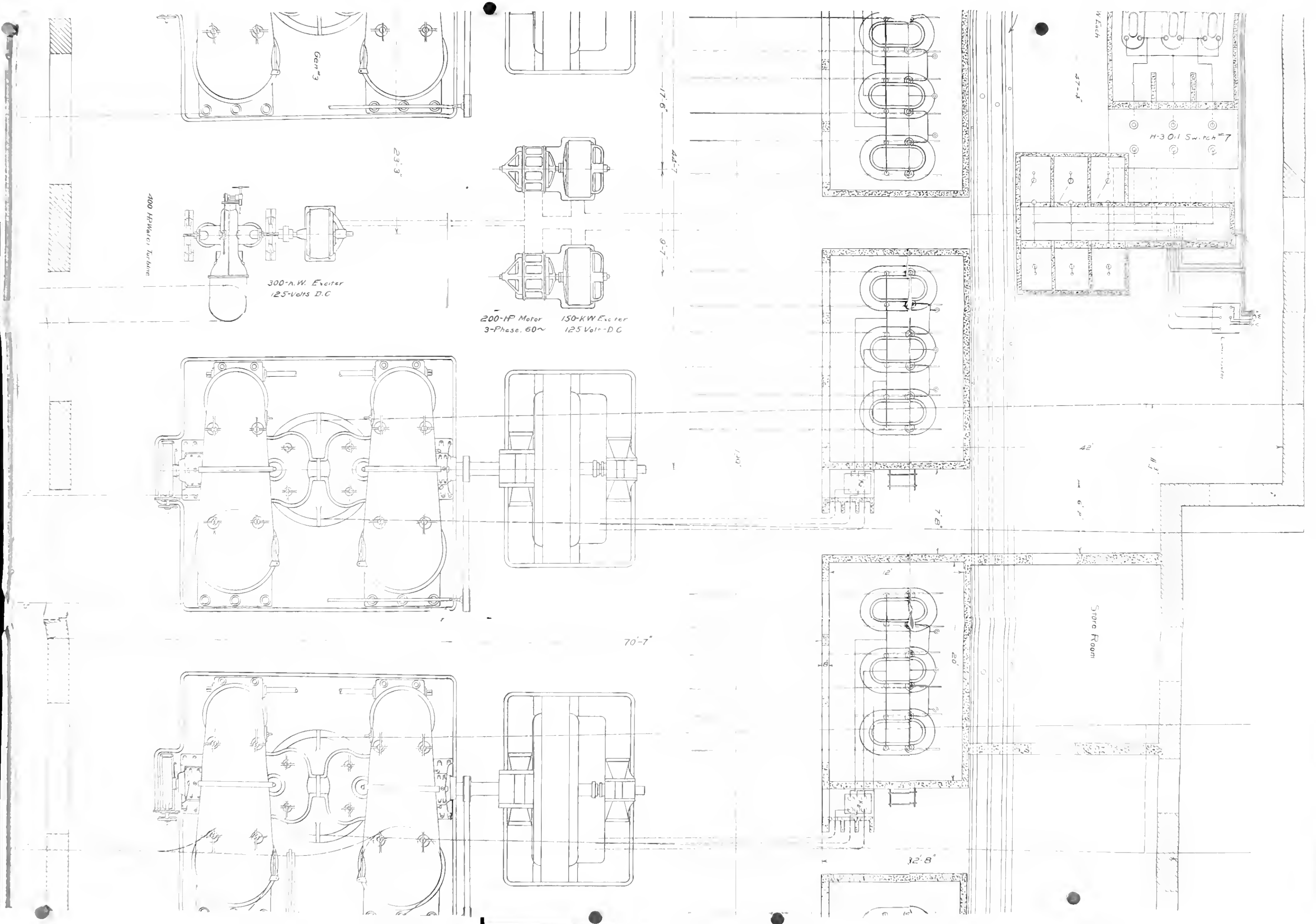
each motor driven exciters is 150 kw. and each is driven by a 200 horsepower motor. The turbo exciter is rated at 300 kw. and is driven by a 400 horsepower turbine.



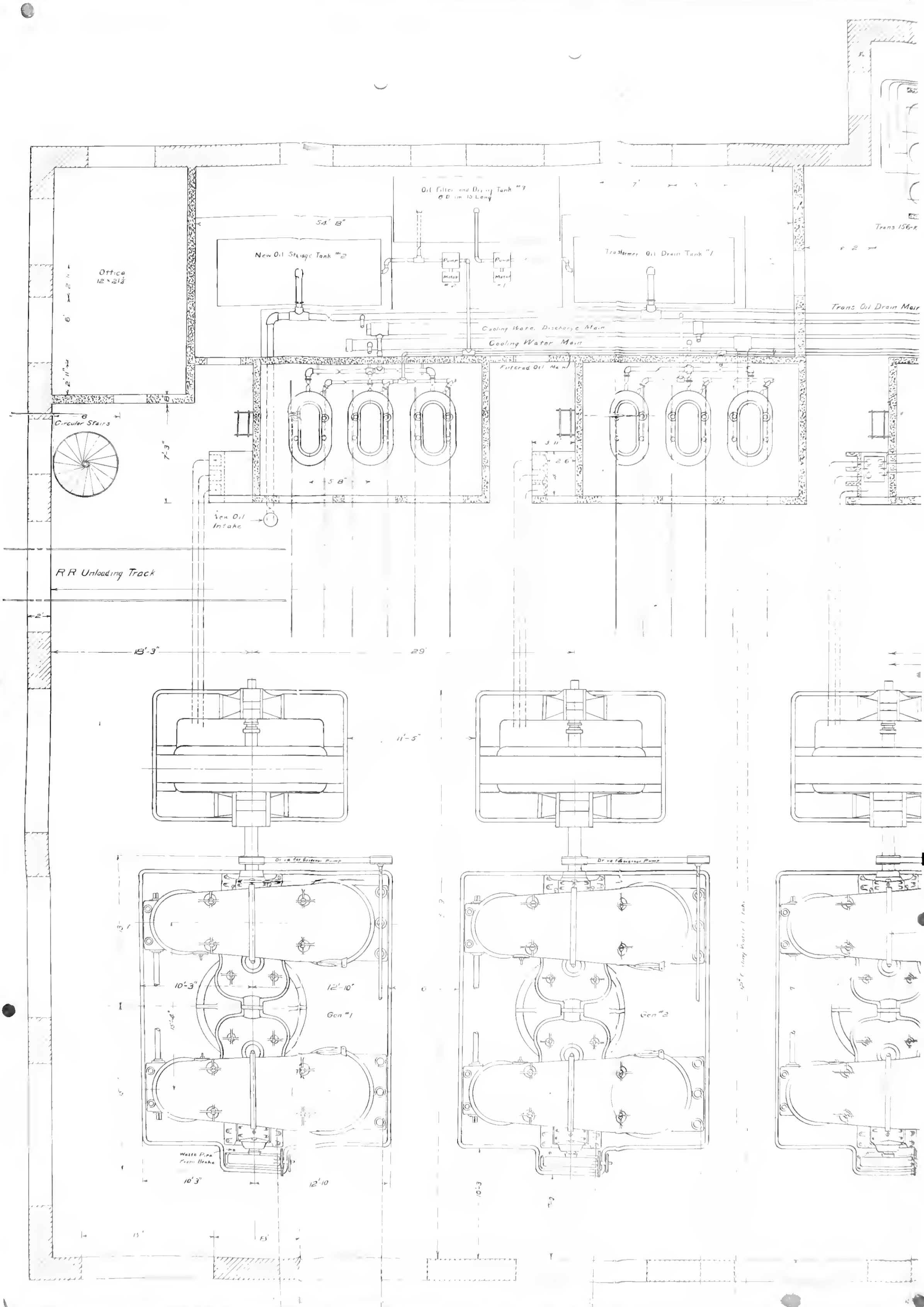
PLAN VIEW
OF
POWER HOUSE
FOR THE
PROPOSED HYDRO-ELECTRIC
POWER DEVELOPMENT
ON THE
TALLAPOOSA RIVER
TALLAPOOSA CO. ALA.

A THESIS
TO
ARMOUR INSTITUTE OF TECHNOLOGY
BY
Dwight A. Whitaker
Frazold A. P. Langstaff.
Ralph R. Ross

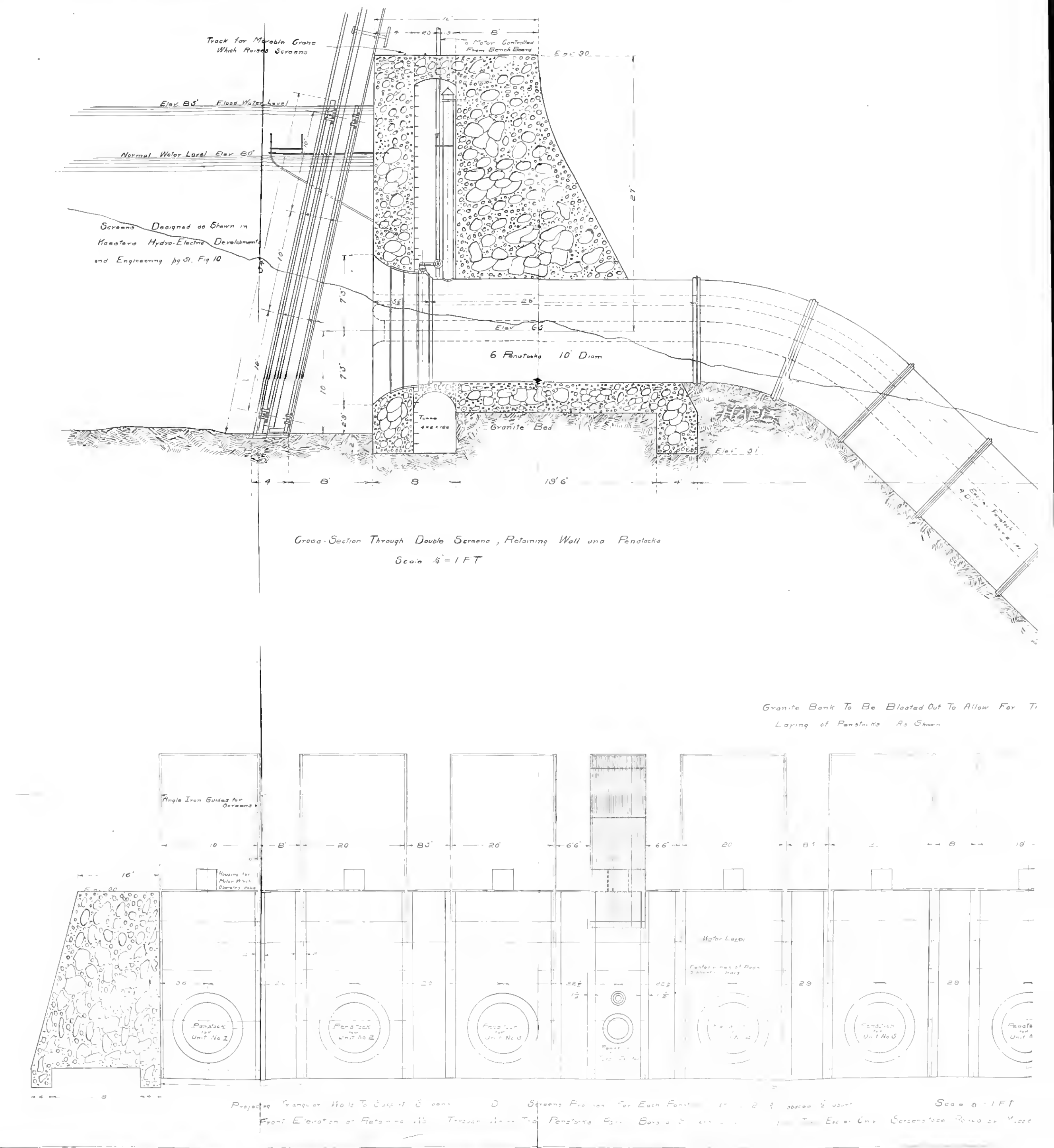
PLATE #5.
Scale 1" = 4'



Gen No 3
400 HP Water Turbine
300-kW Exciter
125-Volts D.C
200-HP Motor
3-Phase. 60~
150-KW Exciter
125 Volt-D.C
H-3 Oil Switch No 7
Store Room
17'-6"
23'-3"
9'-7"
70'-7"
42'
7'-8"
12'
20'
32'-8"



Office
12 × 21½
Circular Stairs
New Oil Storage Tank #2
54' 8"
Oil Filter and Drying Tank #3
Pump
Motor
Transformer Oil Drain Tank #1
Trans 156-K
Trans Oil Drain Main
Cooling Water Discharge Main
Cooling Water Main
Filtered Oil Main
New Oil Intake
R R Unloading Track
18'-3"
29'
11'-5"
Drive for Governor Pump
Gen #1
Gen #2
10'-3"
12'-10"
Waste Pipe From Brake



Track for Movable Crane Which Raises Screens
Motor Controlled From Bench Board
Elev. 90
Elev. 85' Flood Water Level
Normal Water Level Elev. 80'
Screens Designed as Shown in Kootenay Hydro-Electric Development and Engineering pg 51. Fig 10
6 Penstocks 10' Diam
Elev 63
Tunnel
Granite Bed
Elev. 51'
Cross-Section Through Double Screens, Retaining Wall and Penstocks
Scale 1/4" = 1 FT
Granite Bank To Be Blasted Out To Allow For The Laying of Penstocks As Shown
Angle Iron Guides for Screens
Housing for Motor Which Operates Valve
Water Level
Penstock for Unit No 1
Penstock for Unit No 2
Penstock for Unit No 3
Penstock for Unit No 5
Scale 1/8" = 1 FT

SIDE ELEVATION

OF

SCREENS PENSTOCKS & PLANT

FOR THE

PROPOSED HYDRO-ELECTRIC POWER DEVELOPMENT

ON THE

TALLAPOOSA RIVER

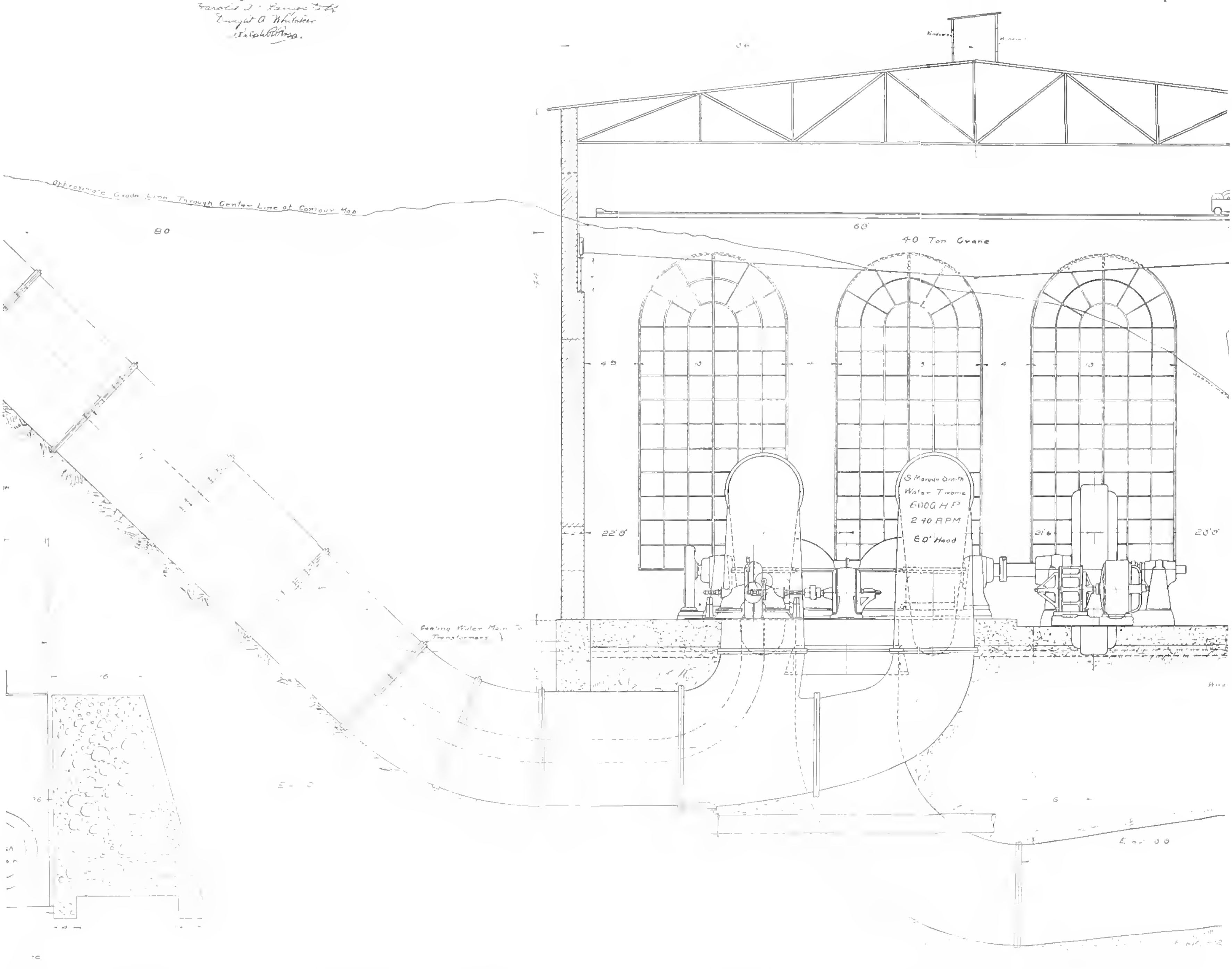
TALLAPOOSA CO. ALA.

A THESIS

TO

ARMOUR INSTITUTE OF TECHNOLOGY

BY



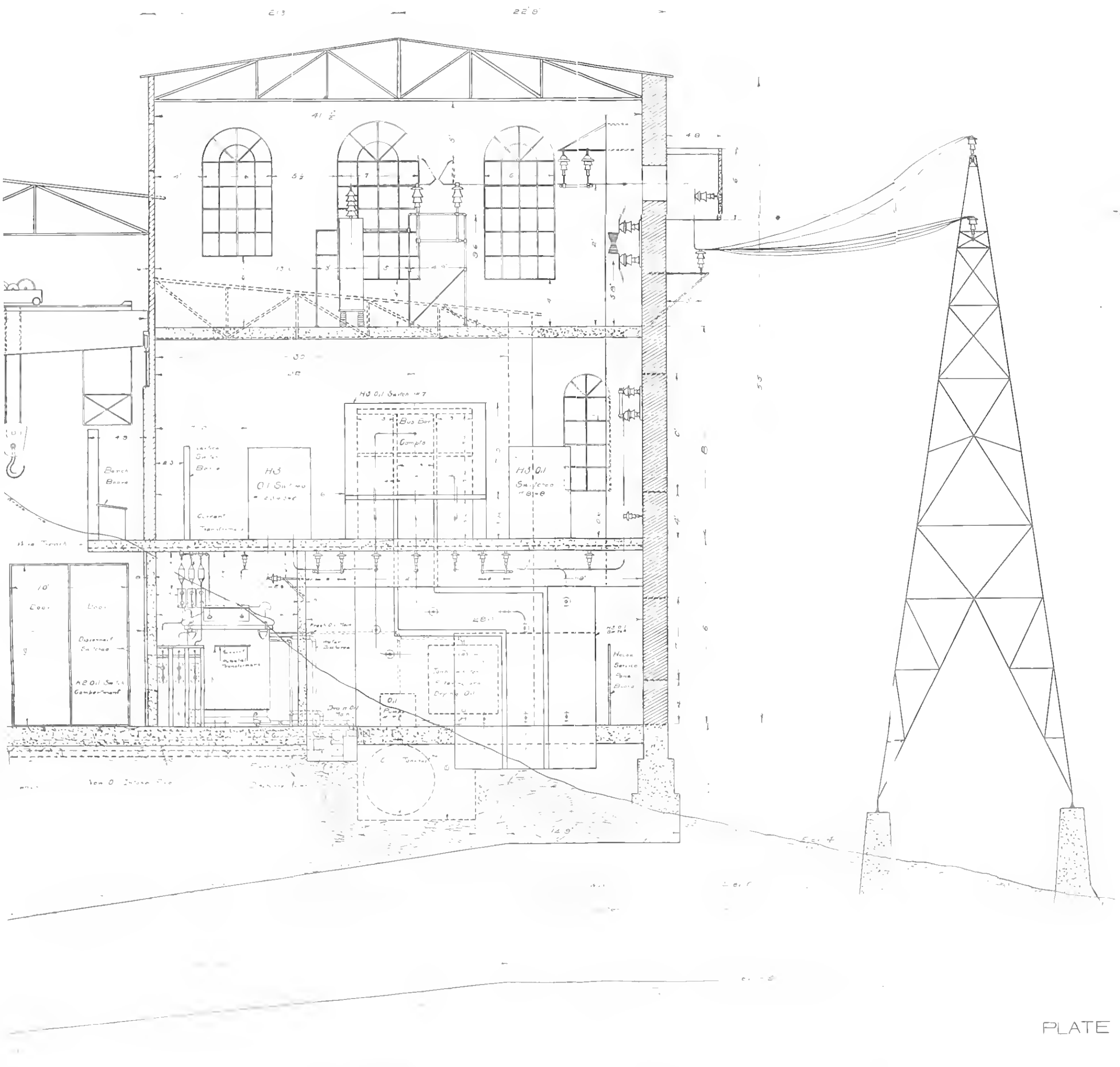


PLATE #4

WIRING DIAGRAM

FOR THE

PROPOSED HYDRO-ELECTRIC POWER DEVELOPMENT

ON THE

TALLAPOOSA RIVER

TALLAPOOSA CO. ALA.

A THESIS

TO

ARMOUR INSTITUTE OF TECHNOLOGY

BY

Harold A. P. Langstaff

Ralph R. Ross

Dwight A. Whitaker

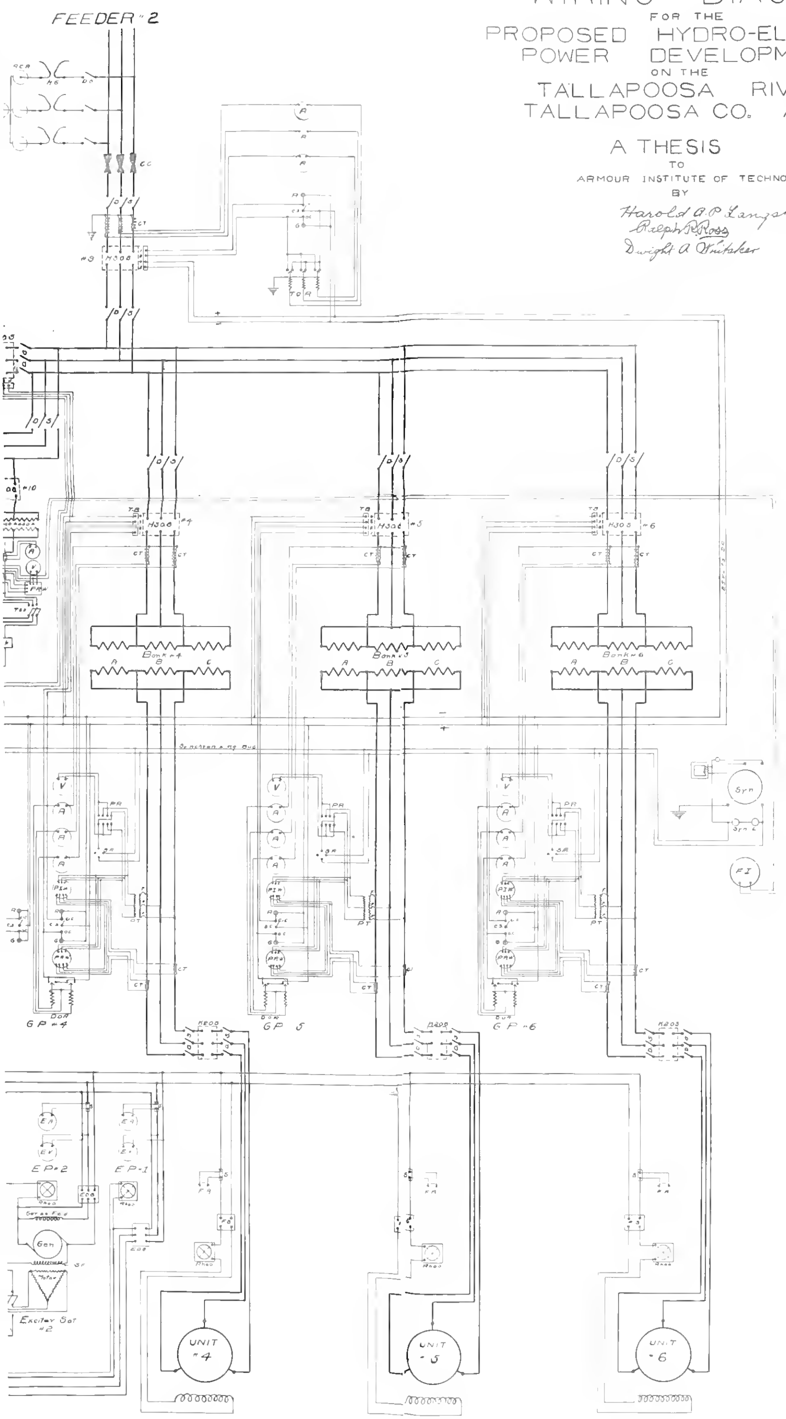


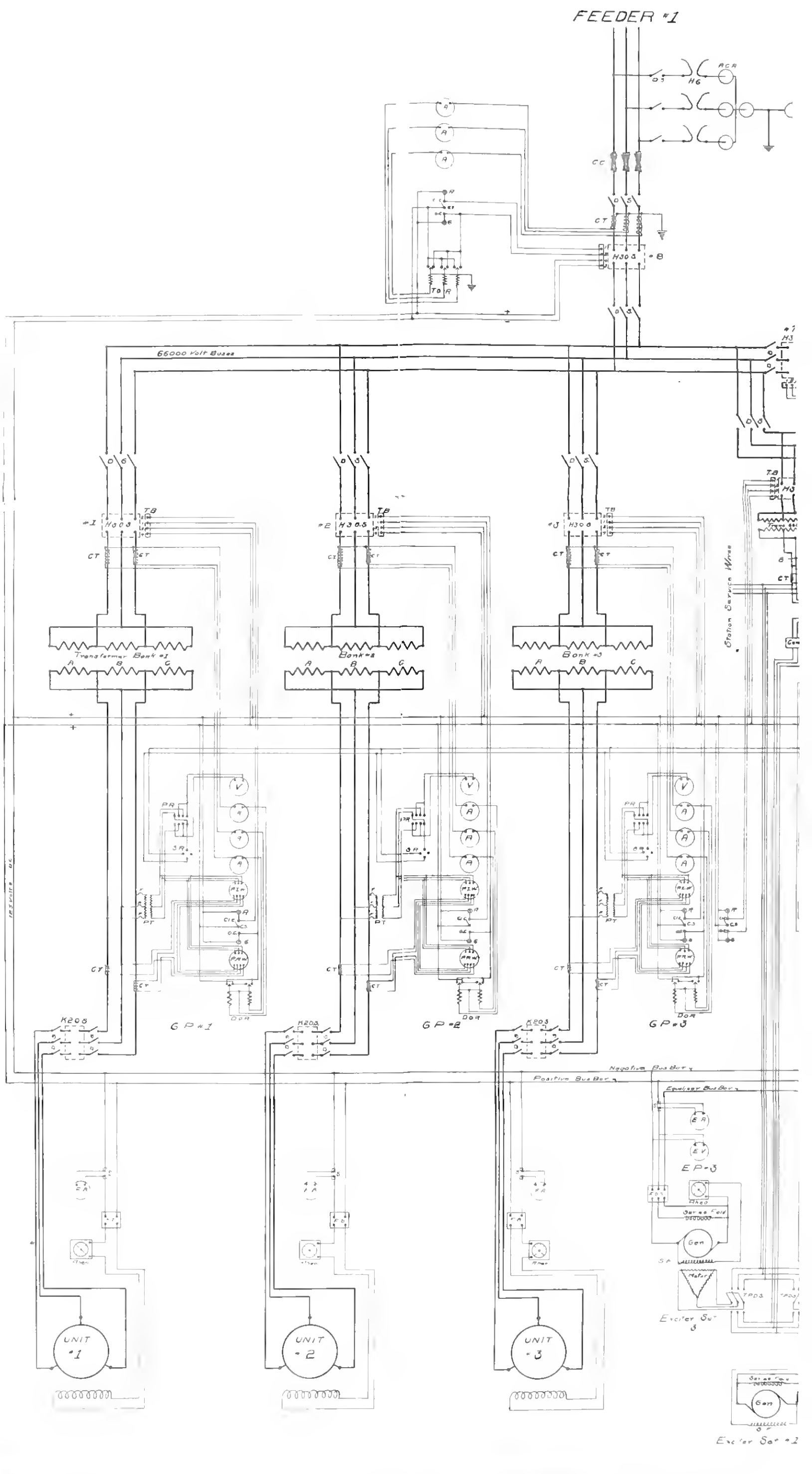
PLATE #9

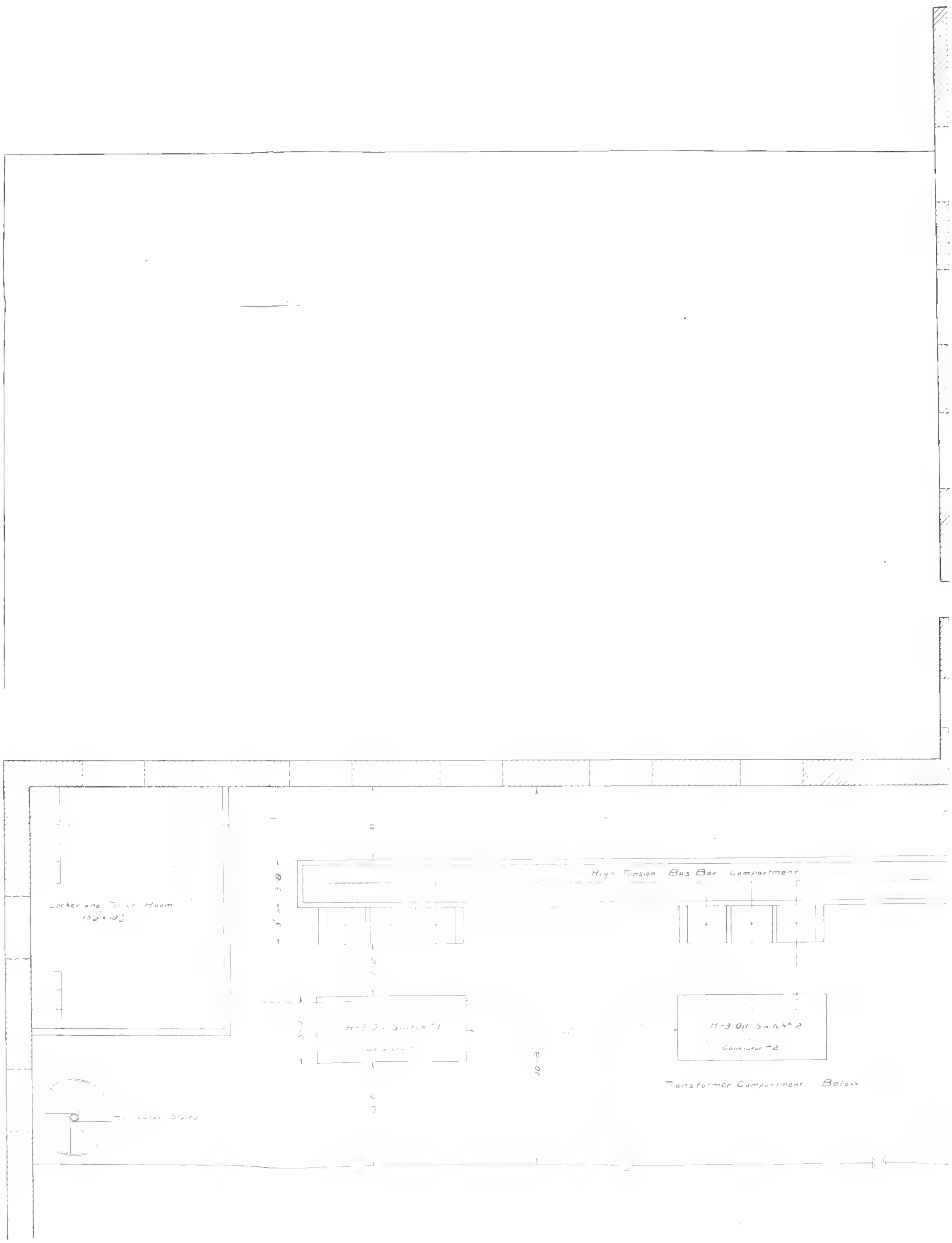
KEY

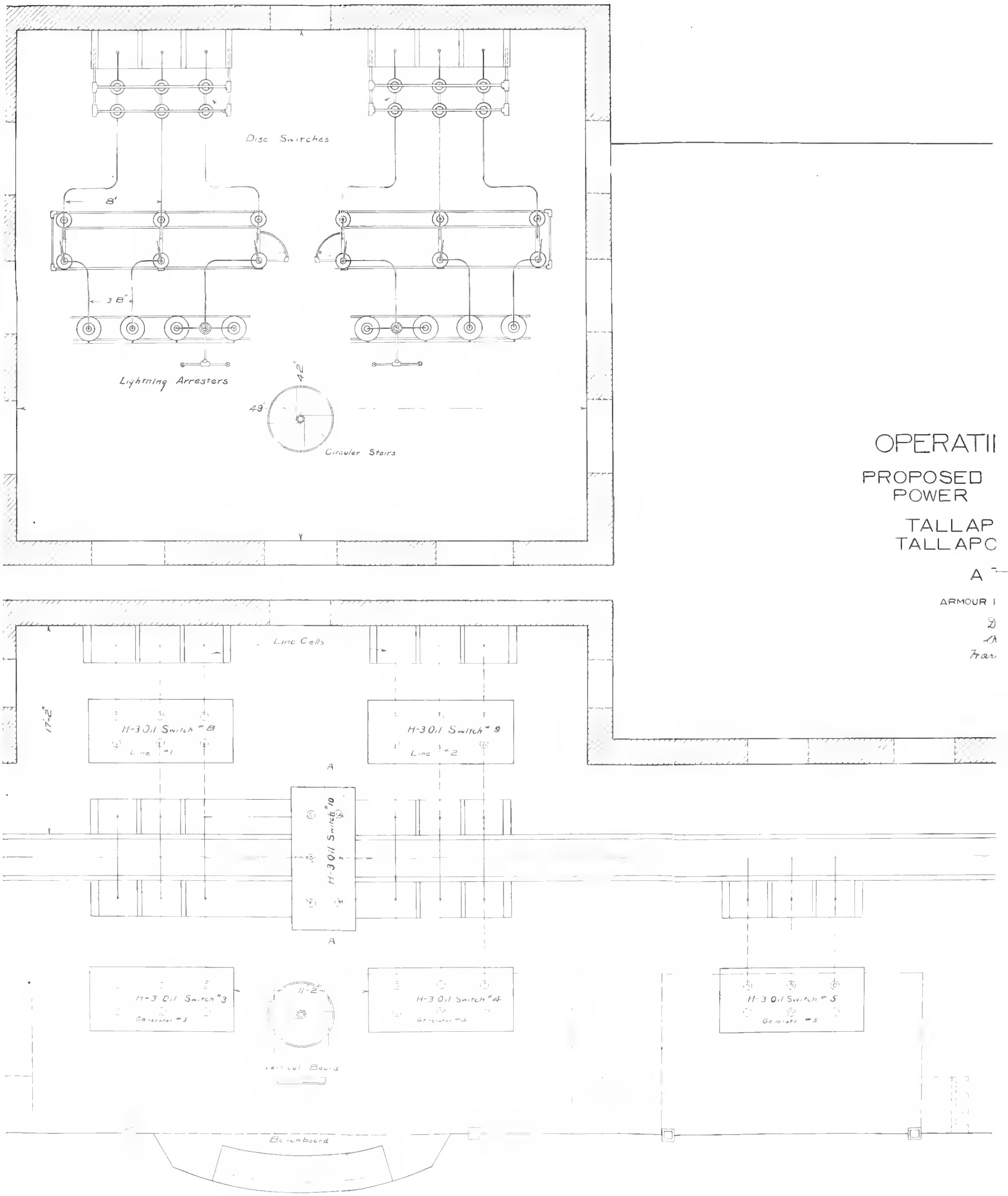
A	Ammeter (AC)
V	Voltmeter (AC)
F	Fuse
S	Shunt
PIW	Polyphase Indicating Wattmeter
PRW	Polyphase Recording Wattmeter
PR	Potential Receptacle
PT	Potential Transformer
CT	Current Transformer
Rheo	Rheostat
SR	Synchronizing Receptacle
FA	Field Ammeter (DC)
FS	Field Switch
EOS	Exciter Oil Switch TPST Solenoid Operated
H3OS	H3 Oil Switch TP Motor Operated
TB	Terminal Block of H3OS
DOR	Double Pole Overload Time Limit Relay
TOR	Triple Pole Overload Time Limit Relay
DS	Disconnect Switch
K2OS	K2 Oil Switch Triple Pole Overload - Hand Operated
EV	Exciter Voltmeter (DC)
HG	Horn Gap
ACA	Aluminum Cell Arrester
CC	Choke Coil
R	Red Lamp
G	Green Lamp
TSS	Triple Pole Single Throw Switch
Comp	Compensator
TPDS	Triple Pole Double Throw Switch
SF	Shunt Field
EA	Exciter Ammeter (DC)
CS	Controlling Switch
Syn	Synchronoscope
Syn L	Synchronizing Lamps
FI	Frequency Indicator
GP	Generator Panel
EP	Exciter Panel
OC	Opening Contact
CIC	Closing Contact

UNITS
3500 KVA ALTERNATORS
3 PHASE 60 CYCLES
6600 VOLTS 240 R.P.M.
Type ATB 30.

TRANSFORMERS
1250 KW 6600Δ-66000Δ
SINGLE PHASE
Water Cooled Oil Insulated

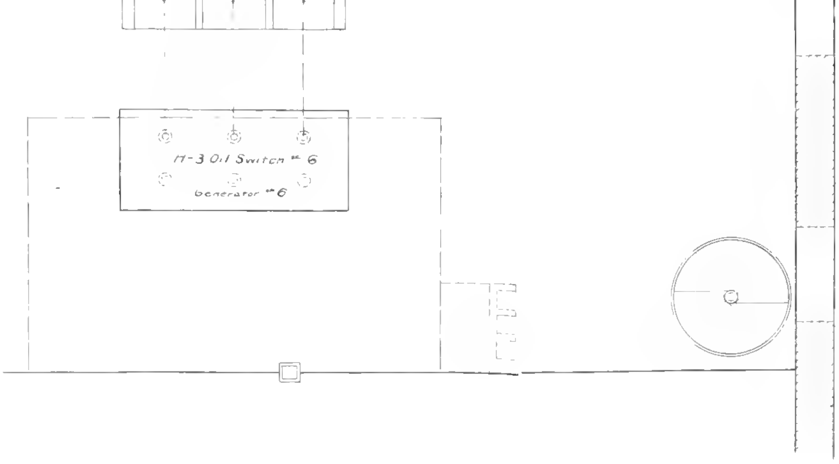



Locker and Toilet Room
High Tension Bus Bar Compartment
H-3 Oil Switch #2
Generator #2
Transformer Compartment Below
30-8
Stairs

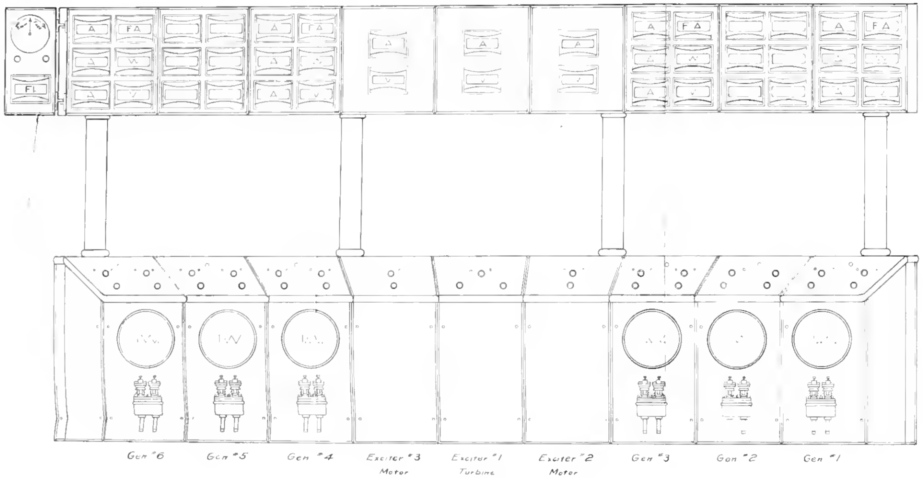

Disc Switches
8'
3 8"
Lightning Arresters
42'
49'
Circular Stairs
Line Cells
17-2"
H-3 Oil Switch #8
Line #1
H-3 Oil Switch #9
Line #2
A
H-3 Oil Switch #10
A
H-3 Oil Switch #3
Generator #3
11-2"
H-3 Oil Switch #4
Generator #4
H-3 Oil Switch #5
Generator #5
Benchboard
OPERATI
PROPOSED
POWER
TALLAP
TALLAPC
A
ARMOUR I

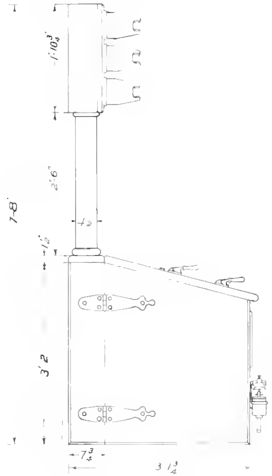
NG GALLERY
FOR THE
HYDRO-ELECTRIC
DEVELOPMENT
ON THE
OOSA RIVER
OSA CO. ALA.

THESIS
TO
NSTITUTE OF TECHNOLOGY
BY

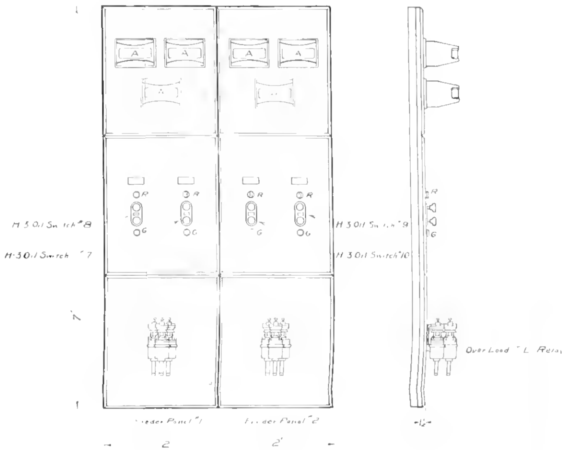


PLATES #s 6-7
Scale 4'=1"

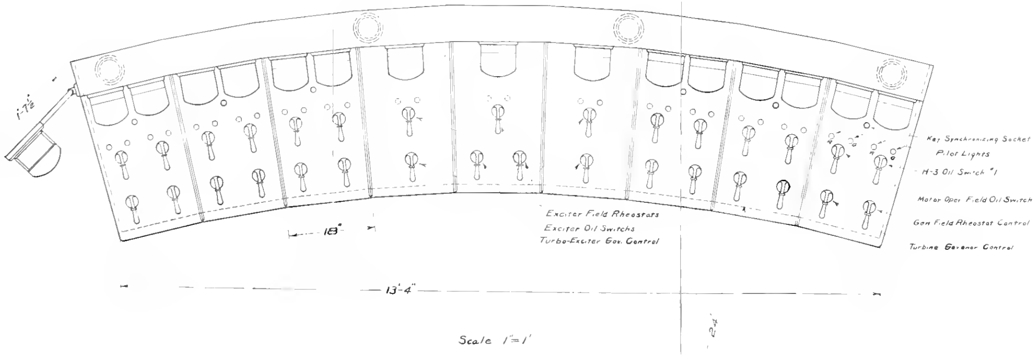




BENCHBOARD



VERTICAL BOARD



Scale 1"=1'

SWITCHBOARDS
FOR THE
PROPOSED HYDRO-ELECTRIC POWER DEVELOPMENT
ON THE
TALLAPOOSA RIVER
TALLAPOOSA CO. ALA.

A THESIS
TO
ARMOUR INSTITUTE OF TECHNOLOGY
BY

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PLATE #8.

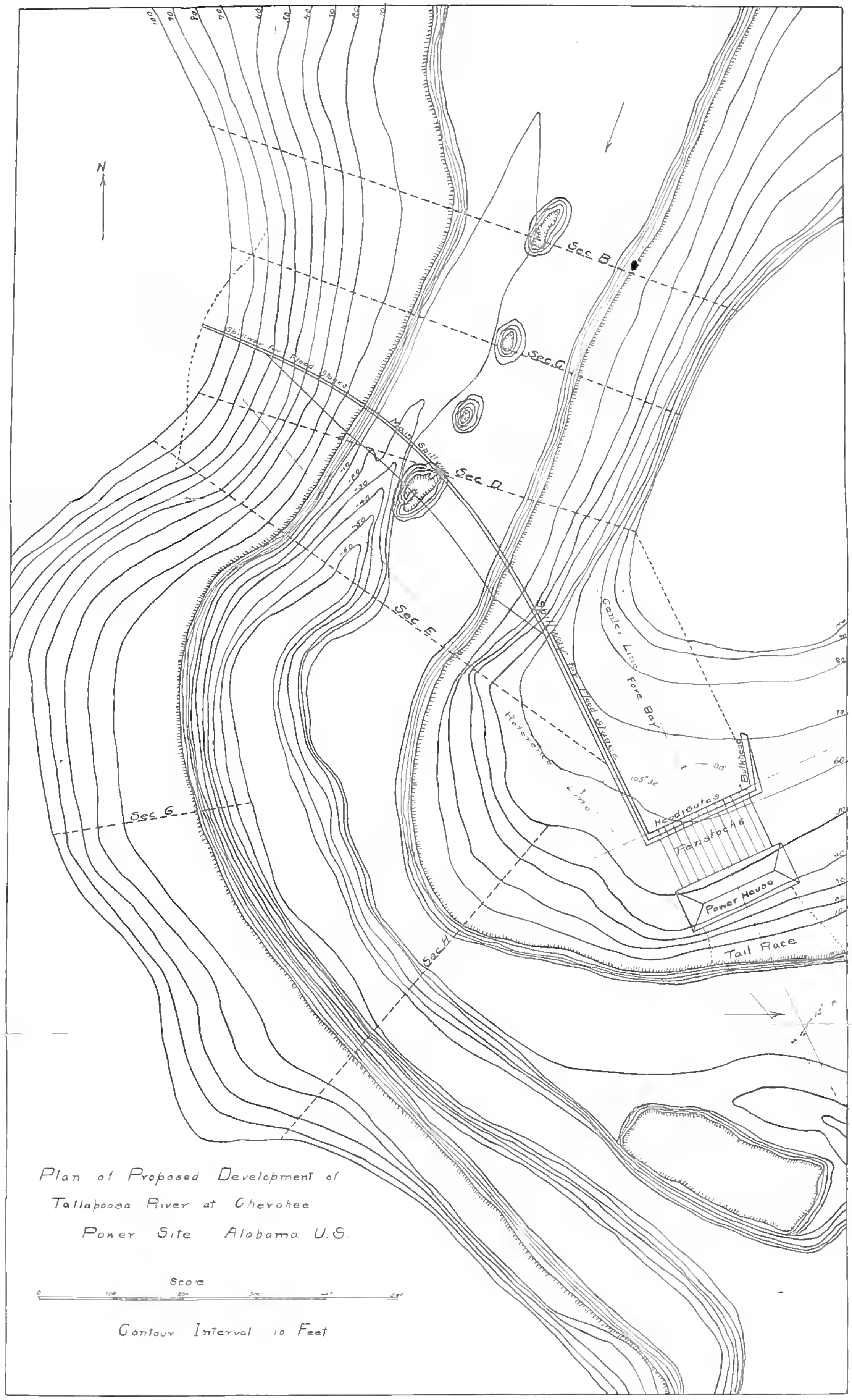
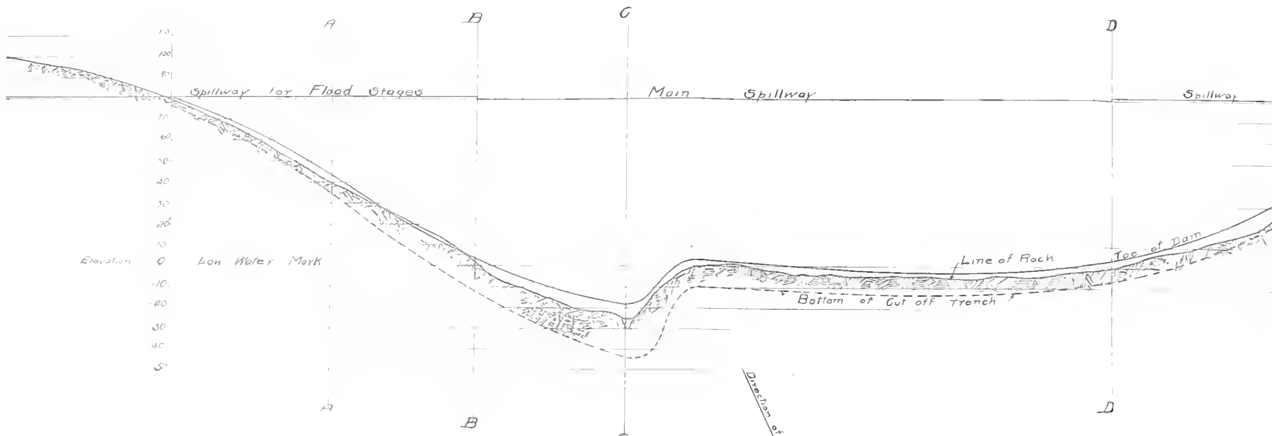
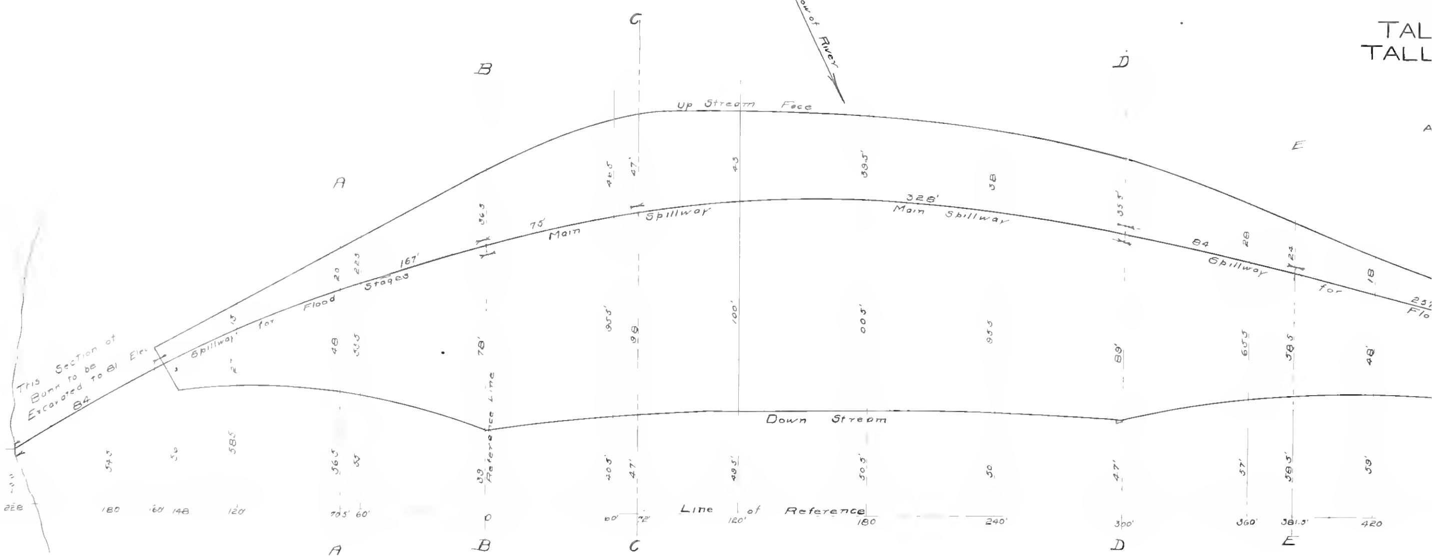

Plan of Proposed Development of
Tallapoosa River at Cherokee
Power Site Alabama U.S.
Scale
Contour Interval 10 Feet
N
Sec B
Sec C
Sec D
Sec E
Sec G
Sec H
Spillway for Flood Stages
Main Spillway
Center Line Fore Bay
Reference Line
Bulkhead
Headgates
Penstocks
Power House
Tail Race

PLATE #1.

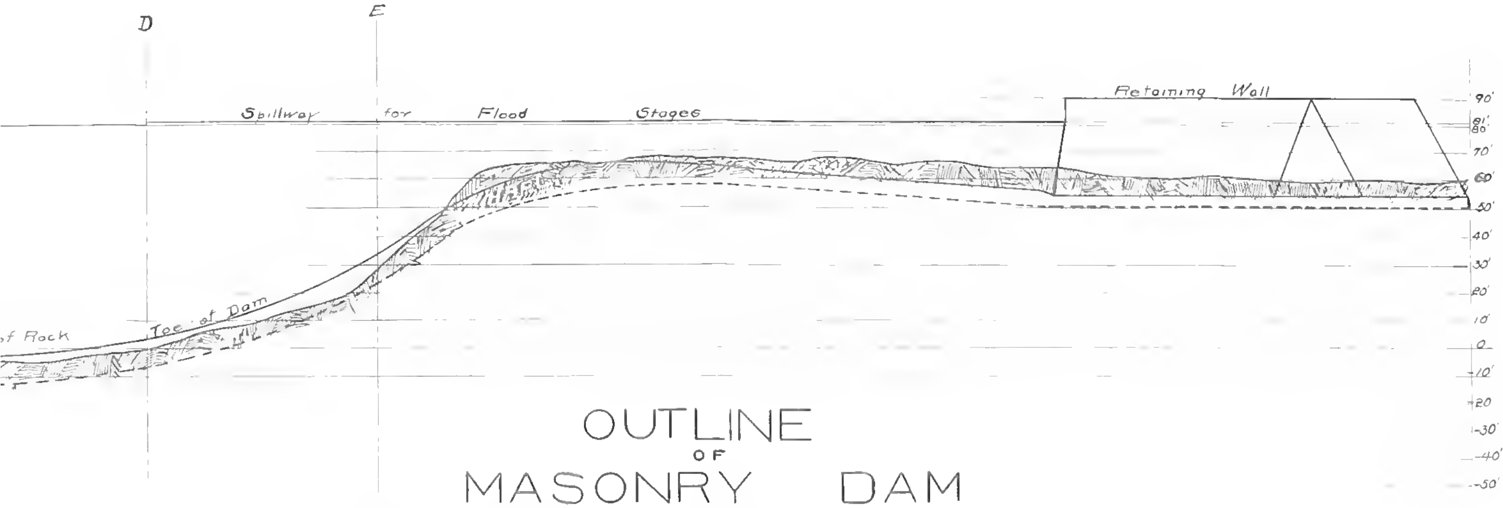
PROFILE VIEW



MAS
PROPOS
POWE
TAL
TALL



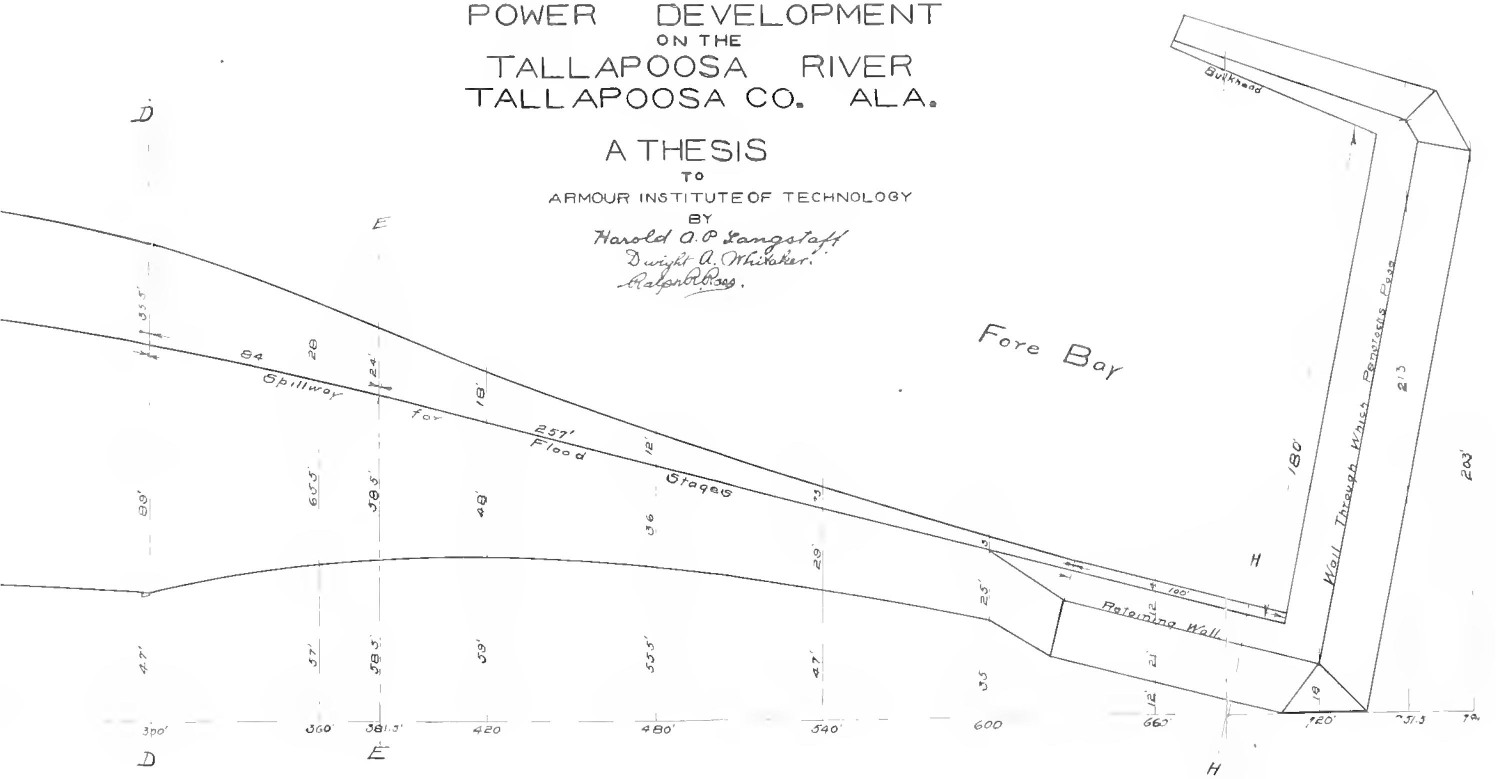
PLAN VIEW.



OUTLINE
OF
MASONRY DAM
FOR THE
PROPOSED HYDRO-ELECTRIC
POWER DEVELOPMENT
ON THE
TALLAPOOSA RIVER
TALLAPOOSA CO. ALA.

A THESIS
TO
ARMOUR INSTITUTE OF TECHNOLOGY
BY

Harold A. P. Langstaff
Dwight A. Whitaker.
Ralph B. Ross.



Scale 1" = 30 FT

PLATE # 3

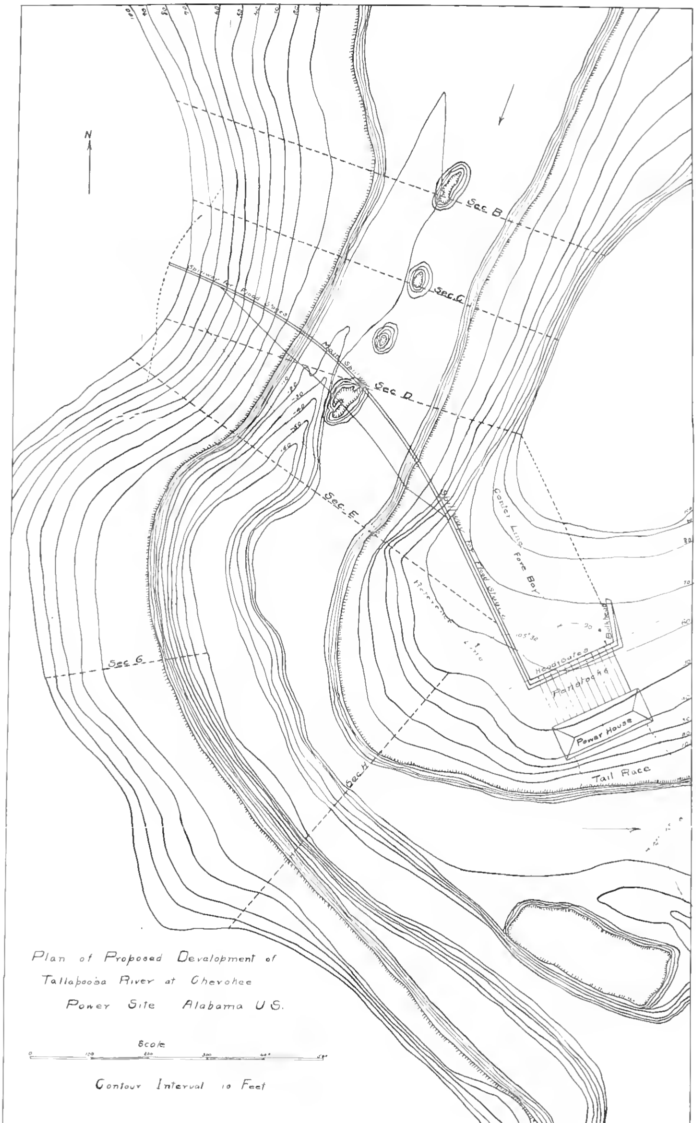
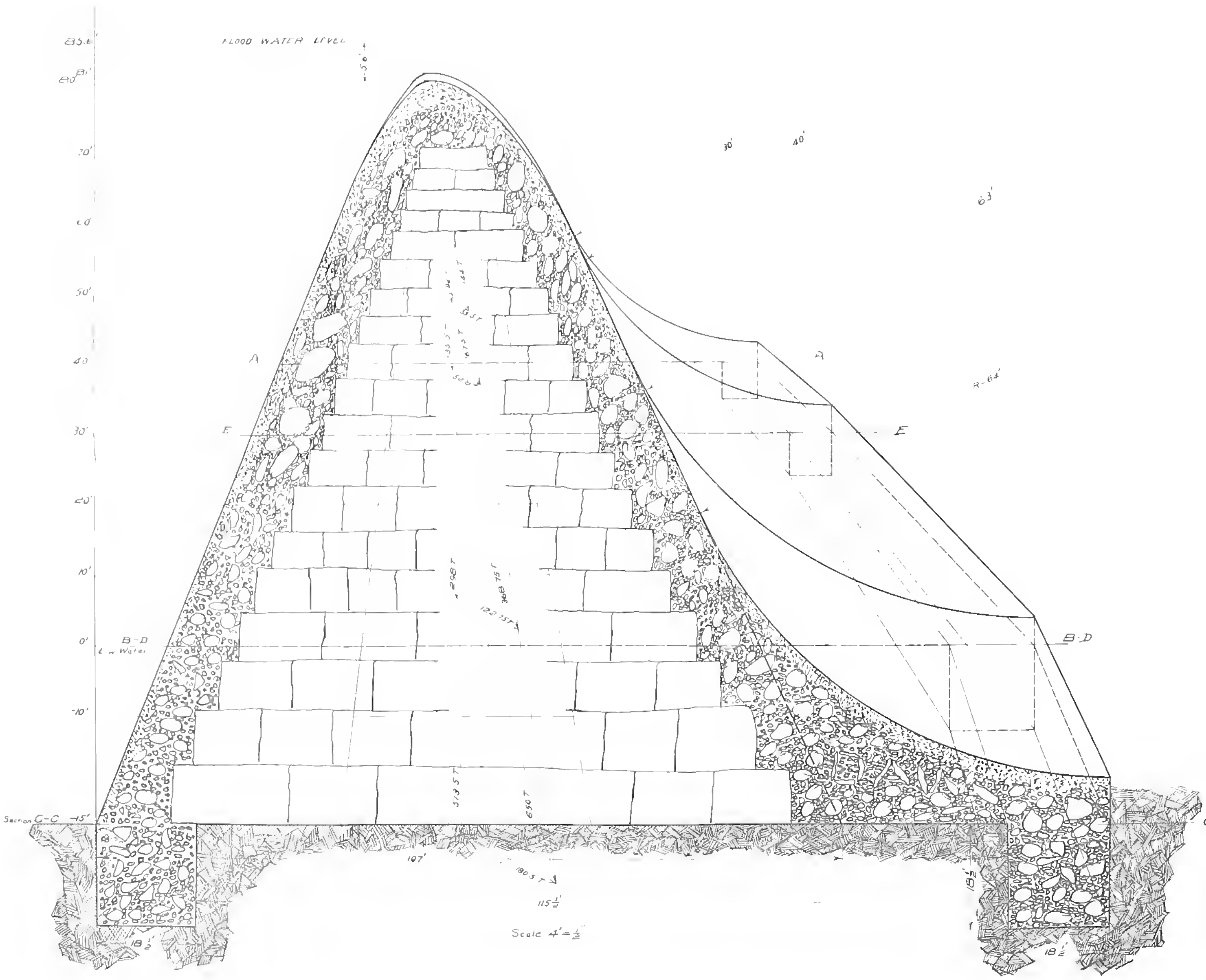
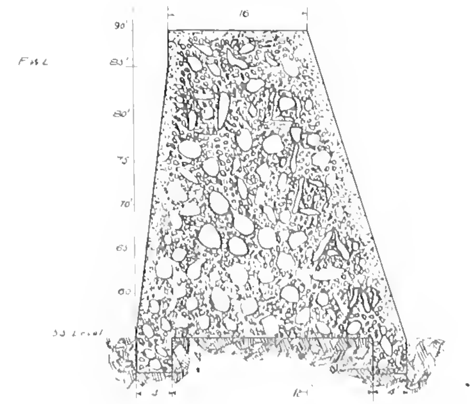

N
Sec. B
Sec. C
Spillway for Flood Slues
Main Spillway
Sec. D
Sec. E
Center Line Fore Bay
Bulkhead
Head Gates
Penstocks
Power House
Tail Race
Sec. G
Sec. H
Plan of Proposed Development of
Tallapoosa River at Cherokee
Power Site Alabama U.S.
Scale
Contour Interval 10 Feet

PLATE #1





MASONRY DAM
FOR THE
PROPOSED HYDRO-ELECTRIC
POWER DEVELOPMENT
ON THE
TALLAPOOSA RIVER
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PLATE #2